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MANUAL

ON

FARM

WATER AND PLUMBING

SYSTEMS

RURAL ELECTRIFICATION ADMINISTRATION
U. S. DEPARTMENT OF AGRICULTURE

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MAR 8 1945

FARM WATER AND PLUMBING SYSTEMS

A complete water and plumbing system on a farm consists of several different units. Rarely will an installation include all of the possible units, and some of the possible units will occur only infrequently. The following are the units most likely to be encountered:

1. Pump;
2. Motor;
3. Automatic motor switch;
4. Water storage tank;
5. Automatic air volume control;
6. Safety pressure release;
7. Water piping;
8. Water softener;
9. Water heater;
10. Kitchen sink;
11. Lavatory;
12. Water closet;
13. Bath tub;
14. Shower;
15. Laundry tubs;
16. Fixture drains;
17. Soil or waste stack (vent and vertical sewage disposal pipe);
18. House drain;
19. Sewage disposal means;
20. Grease trap;
21. Dairy water heater;
22. Watering troughs;
23. Individual livestock drinking cups;
24. Lawn and garden watering equipment.

Often a farmer will install only a portion of his complete system at a time. When this is done, he should be encouraged to first plan the complete system so that he may later merely add to what is already installed rather than having to replace parts of it.

This manual is intended to give a general working knowledge of the various units involved. It is not instructions on how to make installations.

Well Protection

In some parts of the country, most farm wells are contaminated with various colon bacilli. In all parts of the country many wells are contaminated. The source of these bacilli may be either men or animals, but their presence shows that undesirable waste materials are entering the wells. Absence of disease in persons drinking water from these wells is due to the fact that the men or animals whose waste products enter the wells are not carriers of disease organisms so that only harmless bacilli get into the water. Such wells are a health hazard. Farmers should be urged to protect their wells from contamination before installing electric pumps. Many ordinances and regulations require such protection before fluid milk can be sold by the farmer or before milk of the higher grades can be sold.

Contamination enters wells from two sources--(1) surface material including surface water, and (2) subsurface seepage.

Surface material should be excluded by grading around the well so that all surface drainage is away from it and by covering the well with a carefully built concrete curb and watertight seal around the pump pipe. No pump should be placed in a pit over the well unless good drainage for the pit is provided.

Subsurface seepage is a more complex problem. It may be of local origin in which case it is likely through the upper layers of the soil. As protection against this local seepage, the area for 100 feet or more around the well should be kept free of contaminating wastes. Barnyards, chicken yards, etc. should be downgrade from the well, and the well should be cased watertight for at least 10 feet below the surface of the ground. (See figure 1).

Contamination which enters the ground water may travel in this water and make wells long distances, in some cases even miles, from the source of the contamination unfit for supplying drinking water. Contamination of this sort can be determined only after surface or shallow subsurface contamination is eliminated by proper grading, curbing, and casing of the well. The cure is to eliminate the source of the contamination or to drill a new well which taps another source of underground water. Tracing these sources of contamination may be difficult. It is usually done by placing dyes in possible sources and seeing if the color appears in the water in the well. Cesspools are rather common sources of contamination of the underground water. Their use can be justified only in very rare and unusual cases.

Most health officials have facilities for testing well water for purity or have access to such facilities.

Health authorities are glad to recommend simple methods of disinfecting contaminated wells.

It is good practice to disinfect every well before the water is first used, and after every time that the cover is removed or the pipe drawn from the well. Taste, odor, or color of the water are not adequate indicators of its freedom from disease organisms.

In general, deep wells are safer sources of water than shallow wells.

Water Systems

The term "Water System" as used by the commercial trades means the "package" of units consisting of motor, pump, storage tank, and air and electric controls for this "package", although some "systems" are sold minus the storage tank, and a few minus the air volume control.

Practically all electric water systems fall within three classifications: (1) gravity, (2) hydropneumatic, and (3) pneumatic.

Gravity Systems

As the name implies, a gravity system is one in which the water flows by gravity through the pipes to the place where it is used. Such systems are

SANITARY WELL PROTECTION

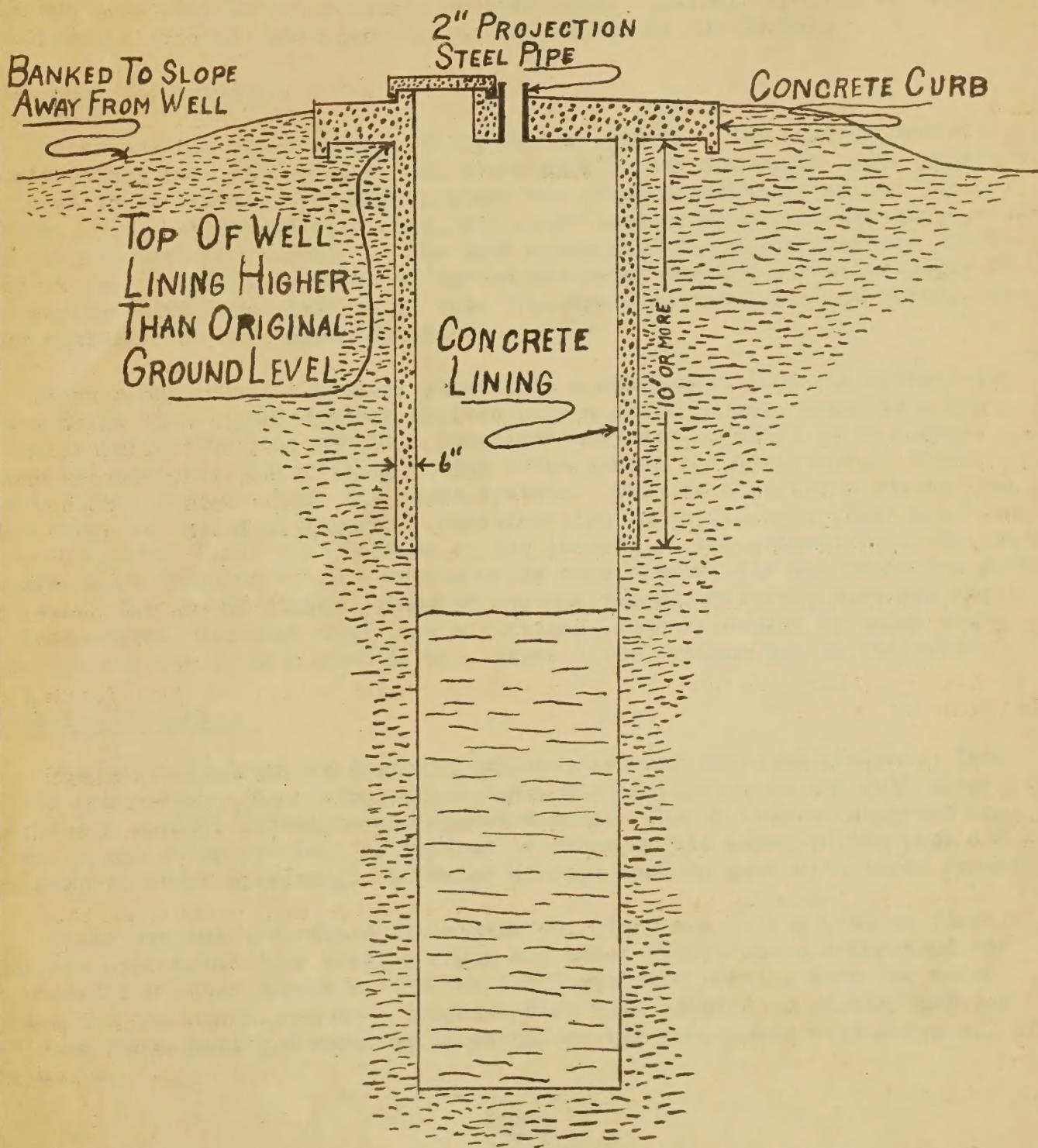


FIGURE 1

УРАИНА
КОЛГОПОЛІСТІ

БАСТАЛІ
СІЛІ

СІЛІ
СІЛІ

СІЛІ

seldom used if electricity is available when the installation is first made, although many of them are later converted satisfactorily to electric operation. In a gravity system, the pump pumps the water into an elevated storage tank from which it flows to the various fixtures. The pump motor may be controlled by a float actuated switch in the elevated tank. The storage tank may be located on a tower, on a hill or in the upper part of a building. Systems operated by windmills are commonly of this type. Electric systems of this type are not sold as "packages" but are assembled by the farmer.

Hydropneumatic Systems

These are the most common electric water systems. The name is derived from the fact that the storage tank contains both air and water under pressure. In loose trade terminology these systems are often incorrectly called pneumatic systems. In a system of this type, the water is pumped into an air-tight storage tank compressing the air in the tank above it. It is the pressure developed by this compressed air which forces the water through the water pipes to the various fixtures. Systems of this type are sometimes, but not often, used with windmill and gas engine power.

Some hydropneumatic systems substitute a small cast iron air chamber for the storage tank. Such systems deliver only a small amount, possibly a cup, of water before the pump starts. Sometimes they are referred to as direct connected systems. Advertising claims often stress the advantage of fresh water direct from the well for these systems. This is strictly a theoretical advantage, not being an important consideration in actual use. They are somewhat cheaper in first cost because of the absence of the storage tank, but they require more frequent motor starting using more electricity and producing greater wear. The use of direct connected systems for general farm purposes should be discouraged, although there are situations, such as summer cottages where they are subject to only limited use, where these systems may be desirable.

Pneumatic Systems

Pneumatic Systems, as the name implies, are air operated systems. From an air compressor and an air storage tank, air is piped into the well where it operates a special submerged air operated pump. When a faucet is opened anywhere in the water system, the reduced pressure on the water in the pipe allows the pump to start operating. No water storage tank is used with these systems.

These systems are relatively expensive. They are little used on farms. They are appropriate for rural garages and other places where compressed air is needed for other purposes--the one air compressor serving both the water system and the other purpose. They are also well adapted to country estates and some farms having several wells since one air compressor will serve all of the wells.

Pumps

Different manufacturers vary the design of their pumps considerably, but certain features are essential and consistent throughout all of them. Water system pumps are divided into two groups: (1) shallow well, and (2) deep well--

on the basis of the physical behavior of water, and into seven types: (1) reciprocating, (2) turbine, (3) centrifugal, (4) rotary, (5) jet, (6) differential, and (7) pneumatic-- on the basis of their design.

Shallow well pumps

In general, the dividing line for determining the selection of a shallow well or a deep well pump is a depth to water of about 22 feet. A shallow well pump functions by removing the air pressure from the water inside of the pump pipe. The normal atmospheric air pressure on the water in the well outside of the pump pipe then forces the water up in the pipe.

Normal atmospheric pressure at sea level is about 14.7 lbs. per square inch. One foot of water exerts a pressure of about .434 lbs. per square inch. Thus, if the pump were capable of removing all of the air pressure from within the pump pipe a shallow well pump should lift water about 33.9 ft. However, no pump is capable of doing this. In practice, the practical suction lifts of pumps vary from about 15 feet to 28 feet, with 22 feet being a good practical overall figure to use until a specific pump is selected. These figures are based on pressures at sea level. As elevation increases the atmospheric pressure decreases and the suction lift of pumps correspondingly decreases. The following table gives the maximum practical suction lift of pumps at different altitudes based on 22 feet at sea level.

<u>Altitude Above Sea Level</u>	<u>Suction Lift of Pump</u>
Sea level	22 ft.
1,320 ft. (1/4 mile)	21 ft.
2,640 ft. (1/2 mile)	20 ft.
3,960 ft. (3/4 mile)	18 ft.
5,280 ft. (1 mile)	17 ft.
6,660 ft. (1 $\frac{1}{4}$ mile)	16 ft.
7,920 ft. (1 $\frac{1}{2}$ mile)	15 ft.
10,560 ft. (2 miles)	14 ft.

Shallow well pumps are usually cheaper than deep well pumps. They are entirely satisfactory in locations where the water level is never deeper than has been indicated in the table above. They do not need to be located directly over the water supply.

Deep Well Pumps

Deep well pumps are used where the depth to water is more than 22 feet (See table under Shallow Well Pumps). They differ from shallow well pumps in that the actual pumping mechanism is lowered into the well so that it is within 22 feet of the water. (This mechanism is usually submerged in the water). The driving mechanism (known as the pumping head) must be adapted to the depth of the well and the volume of water handled, and, for the reciprocating and turbine types, must be located directly over the well. This frequently requires the construction of a pump house or pit over the well for the protection of the machinery.

Reciprocating Pumps (Sometimes called plunger or piston type pumps)

Until about 1940, these were the most common pumps used on electric water systems for both shallow well and deep well operation. As the name implies, this type of pump consists of a piston or plunger in a cylinder together with an appropriate set of valves. Figure 2 and 3 illustrate common reciprocating pumps. Figure 2 illustrates a shallow well pump which is also a double acting pump since each end of the cylinder pumps water independently of the other end. As the plunger moves to the right, water is drawn in through the lower left valve and forced out through the upper right valve. As it moves to the left, water is drawn in through the lower right valve and forced out through the upper left valve. The air chamber serves as a cushion smoothing out the flow of water from the pump. Figure 3 illustrates the cylinder of a deep well reciprocating pump. This cylinder would be lowered into the well. As the plunger moves up in the cylinder, the plunger valves closes, lifting the water above it, and water is drawn in through the foot valve. As it moves down, the foot valve closes and water is forced through the plunger valve. This particular diagram illustrates a cylinder from which the plunger can be withdrawn without removing the well pipe from the well. This is known as an open end cylinder. Closed end cylinders are larger than the well pipe so that the well pipe must be "pulled" and the cylinder disassembled to remove the plunger. Open end cylinders are commonly used in very deep wells while closed end cylinders are most common in wells less than 75 feet deep. The drop pipe below the foot valve may be of any length or may be absent and often a strainer is attached at its lower end. The mechanical construction of the plunger and valves varies with the depth of the well for which the cylinder is built.

Turbine Pumps

Turbine pumps are built both as shallow well and deep well pumps although the smallest deep well ones are usually too large for ordinary farm water systems except for installations requiring very large quantities of water. A turbine pump functions by sweeping a series of vanes at high speed beside a narrow water channel. They are sometimes spoken of as being modified centrifugal pumps. Although there is close similarity to centrifugal pumps in their mechanical construction, their pumping action is quite different.

Figure 4 illustrates a turbine pump.

Turbine pumps for farm water systems are made by several manufacturers. They are particularly smooth in operation. Dirt or fine sand in the water causes the closely fitting surfaces in them to wear very rapidly. When they are used in situations where dirt or sand may be in the water they pump, they should be well protected by very fine screens.

Centrifugal Pumps

Centrifugal pumps function by rotating the water within a circle. This throws the water to the outer edge of the circle where the pump outlet is located and leaves a vacuum at the center of the circle. The pump inlet is at the center. Figure 5 illustrates a centrifugal pump. Until the development of jet pumps within the last decade, centrifugal pumps were rarely used with farm water systems. They are now commonly used with jets and in some cases

without jets. In general, they are adapted to handling large volumes of water at low pressures and very special designs have been necessary for them to operate at the pressures used in water systems. They are very smooth in operation, in this respect being like turbine pumps. They are not self priming although a few manufacturers are equipping them with air separation devices so that when they are once primed they can handle some air with the water without losing their prime.

Rotary Pumps

Rotary pumps consist of two gears running together. Water is carried between the teeth on the outside of each gear but cannot return between them because of the meshing of the teeth. A rotary pump is illustrated in figure 6. Pumps of this type are not now as common on farm water systems as they were a few years ago, but they are still supplied by a few manufacturers. They are more frequently used in pumping from cisterns than from wells. The popularity of these pumps has decreased for two reasons--(1) a little wear on the rotors or housing reduces their pumping ability considerably, and (2) inexpert taking apart and putting together may cause them to stop working, since the plate covering the face of the rotors must fit closely enough to prevent water from leaking between it and the rotors but still must not bind against the rotors. These pumps are most likely to be found on the cheaper systems and can give good service on relatively low water suction lifts when used by farmers who understand the close adjustment necessary when for any reason the cover plate is removed and replaced.

Jet Pumps

Jet pumps are relatively new. They became generally known in the late 1930's and now have become the most popular type of pump. To understand their operation, it is necessary to realize that a jet pump is never used alone but always in connection with a pump of some other type. It is the combination of these two pumps that is commonly known by the trade as a "jet pump" or "ejector pump". The other pump of the combination is most commonly centrifugal, although many are turbines and a few are reciprocating. Any shallow well pump--reciprocating, turbine, centrifugal, or rotary--can be converted to a "jet pump" by adding the jet pump portion of the combination. Some of the first jet pumps to appear on the market were merely attachments for any shallow well pump and their purpose was to convert the shallow well pump to a deep well pump. Jets are now used in some shallow well pumps to increase the suction lifts of the pumps and to increase the pressure which the pumps can develop.

Figure 7 illustrates a jet pump. Water under pressure from the "pump" outlet passes down the drive pipe and is forced at high velocity through the jet nozzle and venturi. As it passes through the venturi this jet of water draws additional water up through the foot valve and forces it up the delivery pipe to within the suction lift of the shallow well pump at the top. The jet nozzle and the venturi must be adapted to the depth of the well.

There are two types of "jets" known respectively as double pipe jets and single pipe jets. The illustration shows a double pipe jet and this is the one used when the well is large enough to admit two pipes. The single pipe jets are used in drilled wells not large enough to admit the two pipes of the double

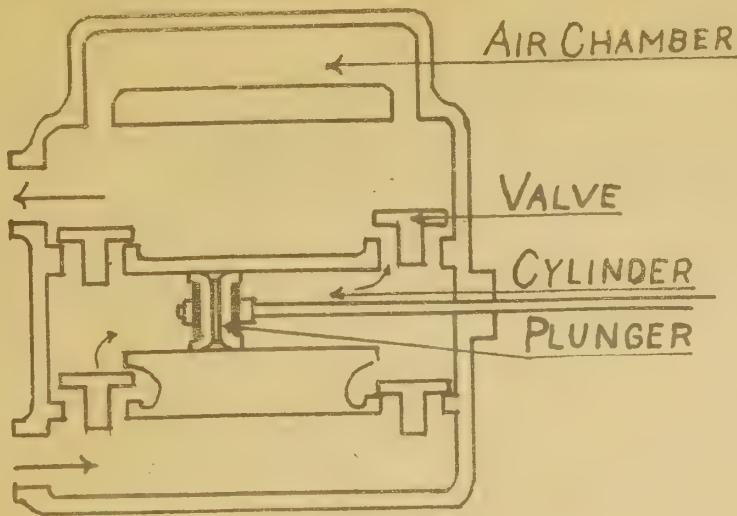


FIGURE 2

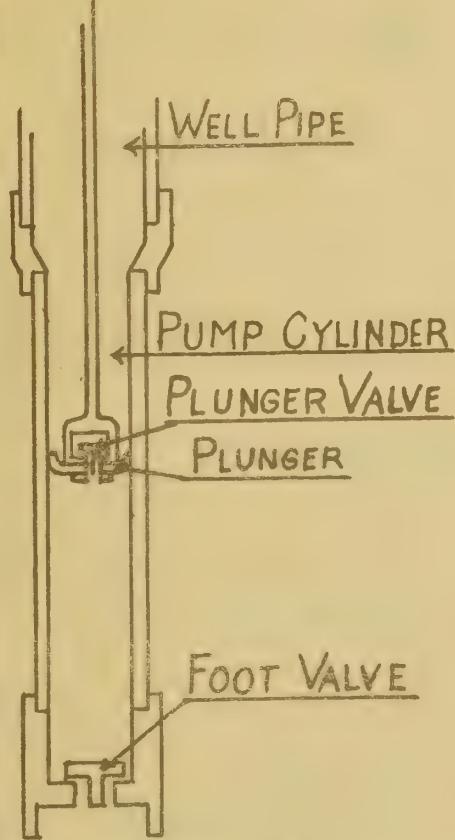


FIGURE 3

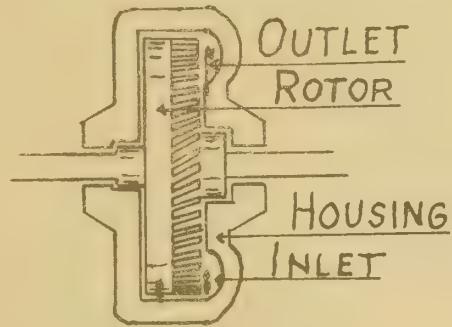


FIGURE 4

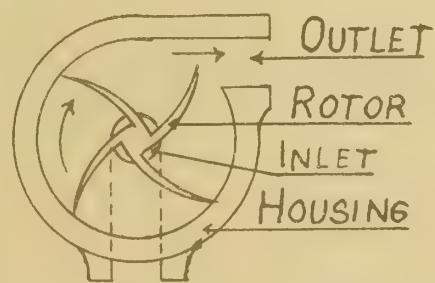


FIGURE 5

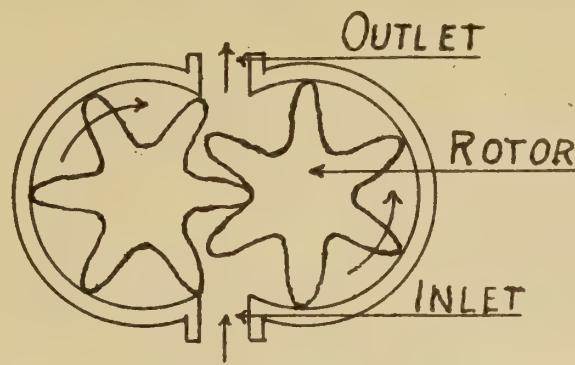


FIGURE 6

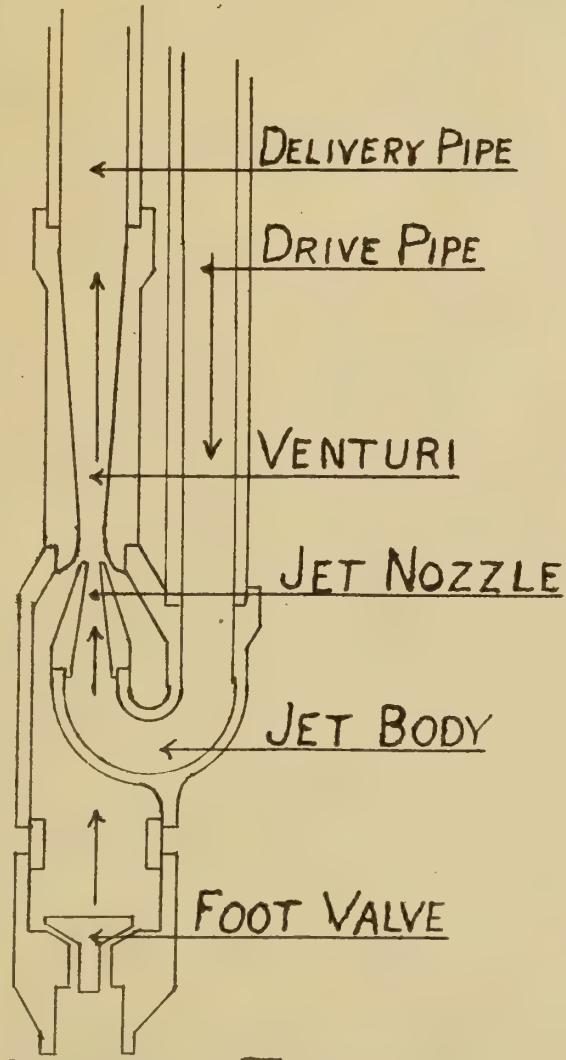


FIGURE 7

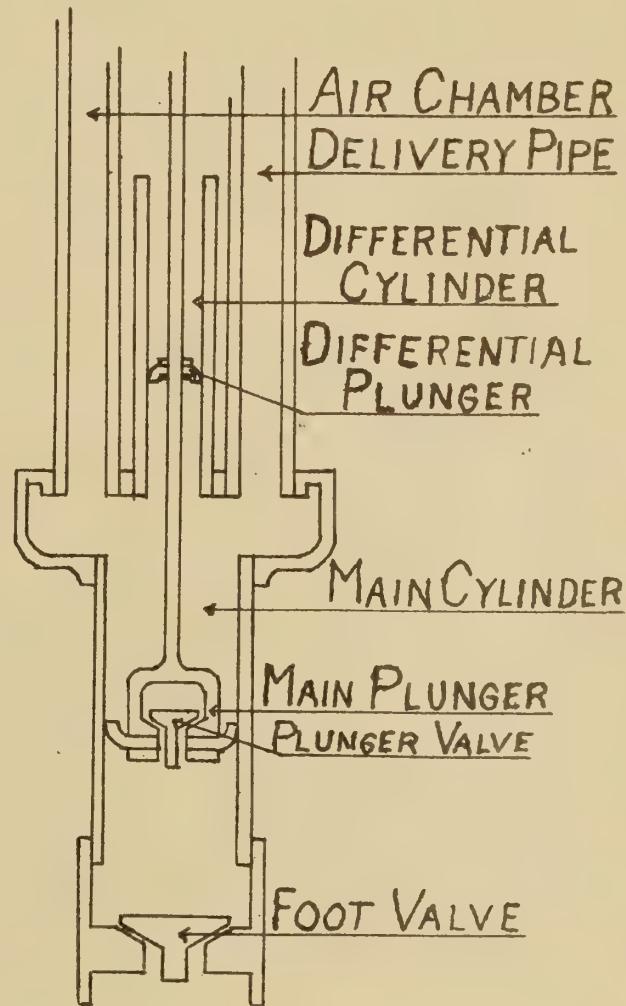


FIGURE 8



pipe jets. They differ from the double pipe jets in that only one pipe with the entire jet assembly on the end of it is lowered into the well where the jet assembly is expanded to make a water tight seal with the well casing. The well casing itself then serves as the drive pipe. Frequently, the single pipe jets are known as "packer" jets because the arrangement on the jet body which expands to make the seal with the well casing is called a packer.

Contrary to the ideas of some enthusiastic individuals, the "jet pump" is not a universal substitute for other types. It is a versatile pump, but there are situations where other pumps are equally satisfactory or to be preferred. Its range of superiority is in wells where the depth to water is between 22 feet and about 80 feet, particularly where it is not desirable to locate the driving mechanism directly over the well. In shallower wells, the "old-fashioned" shallow well pumps are equally satisfactory. While jet pumps are usually recommended by the manufacturers for depths to water of 120 to 150 feet and at least one of them will operate at depths to 300 feet, their efficiency of operation falls at these greater depths to such an extent that farmers are usually well advised to use the "old-fashioned" reciprocating deep well pumps when the depth is more than 80 feet. One big disadvantage of the jet is the seeming mystery of its operation to the average pump service man. Many of these service men locate troubles by blundering hit-and-miss methods.

Differential Pumps

A differential pump is merely a modification of a simple reciprocating pump in such a way that the pump delivers water on both strokes of the plunger thus producing a more even discharge. It is a double acting pump and is used mainly in deep well systems. The differential cylinder may be built into the main cylinder, may be mounted on top of the main cylinder or may be mounted in the driving mechanism at the top of the well. For simplicity of illustration, figure 8 shows the differential cylinder mounted on top of the main cylinder although this type of construction is more common in windmill and hand pumps than in electric pumps. Both the differential plunger and the main plunger are attached to the pump shaft and move together. As the plungers move upward, the main plunger draws water through the foot valve and lifts the water above itself--some of this water going into the differential cylinder and some out of the delivery pipe. As the plungers move downward, water in the lower part of the main cylinder is forced through the plunger valve keeping the entire main cylinder full and the water being forced from the differential cylinder is forced out through the delivery pipe. The air in the air chamber merely acts as a cushion evening out the discharge of water through the delivery pipe.

Air Pumps

Air pumps are used only on pneumatic systems and, therefore, they are rather rare in farm water systems. Their mechanism is relatively complex. Essentially, these pumps consist of closed chambers with appropriate pipe connections and complicated systems of valves. They are submerged in the water in the well. When the pump is full of water, a float actuated system of valves closes the water inlet, closes the air exhaust opening, opens the valve to the discharge pipe, and opens the valve which admits air from the air compressor. The compressed air then forces the water in the pump into the

discharge pipe. Another float and valve arrangement then closes the valve which admits air from the air compressor, closes the valve in the discharge pipe, opens the air exhaust opening so that the air in the pump escapes into the well, and opens the water inlet opening so that the pump again fills with water. The pump continues to pump water into the discharge pipe as long as a faucet anywhere in the water system is open. It stops pumping when all faucets are closed so that the compressed air cannot force more water into the discharge pipe.

Motors

Split phase, capacitor, and repulsion-induction motors are all used on farm water systems. It is questionable whether the split phase motors are desirable, and, when they are used, the motor is larger than is needed for the operation of the pump after it is started. Reciprocating, rotary, and differential pumps start under full load and therefore repulsion-induction motors are most desirable with these types. Turbine and centrifugal pumps pick up their load as they gather speed and are therefore more adequately equipped with capacitor motors. Reciprocating and differential pumps are usually belt driven while the rotors in turbine, centrifugal, and rotary pumps are usually mounted directly on the motor shafts.

All farm pump motors should be equipped with automatic or manually reset over load protection. This is an important point that has been overlooked by many manufacturers.

If the electric service to the pump is from the yard pole; the pump will continue to operate when fire destroys the wiring in the house.

Automatic Motor Switches

Electric "water systems" commonly come equipped with an automatic switch for stopping and starting the motor. This switch is operated by the pressure in the storage tank but is usually mounted on the frame of the pump. If the storage tank and pump are located side by side, a small copper tube may lead from the tank to this switch. Perhaps, more commonly the switch is connected to the delivery pipe from the pump by a small copper tube so that it receives the pressure of the storage tank indirectly through the delivery pipe. The switch is usually adjusted so that it turns the motor on when the pressure in the tank decreases to 20 pounds and turns it off when the pressure reaches 40 pounds. Some of them are adjustable so that this range in pressures can be changed but it is very rare that this is not a satisfactory range.

Water Storage Tanks

Hydropneumatic water storage tanks come in a wide variety of sizes varying from about 12 gallons to several hundred gallons capacity. As a general rule, the 42 gallon size is the smallest that should be recommended for general farm use. If there is a dairy herd of 10 or more cows or if the water is to be used for garden watering, at least an 80-gallon tank should be used. Small pumps pumping from wells that supply water slowly need larger tanks than adequate wells with large pumps.

Water is pumped into the bottom of the tank and as it fills the tank it compresses the air above it. It is this compressed air that furnishes the pressure to force the water through the pipes of the water system. Thus the entire capacity of the tank is not available for water storage. The active water supply will be about 1/4 of the volume of the tank, or a 42-gallon tank will furnish about 10 gallons of water after the pump stops before the pump starts again. The quantity of air in the tank is maintained by the air volume control.

Either a gate or globe valve should be placed in the outlet of the tank so that the water may be shut off when, for any reason, it is necessary to make a repair anywhere in the water piping system, and, unless the tank is very small, a gate valve or a check valve should be between the pump and the tank so the pump can be repaired without draining the tank.

Automatic Air Volume Controls

At all times, water has a certain amount of air dissolved (not mixed) in it. When air pressure on water is increased, as it is when the water is stored in a hydropneumatic tank, more air dissolves in the water. This means that continually the air in the hydropneumatic tank is passing out with the water as it is withdrawn. If the system is to continue to operate properly it must be equipped to replace this lost air in the tank. This is done in several ways.

Deep well reciprocating and differential pumps are usually equipped with a separate cylinder which pumps air with the water into the tank whenever the pump runs. This provides an excess of air. The surplus air is then released from the tank by a valve controlled by a float in the tank. Figure 9 is a diagrammatic illustration of this type of air volume control.

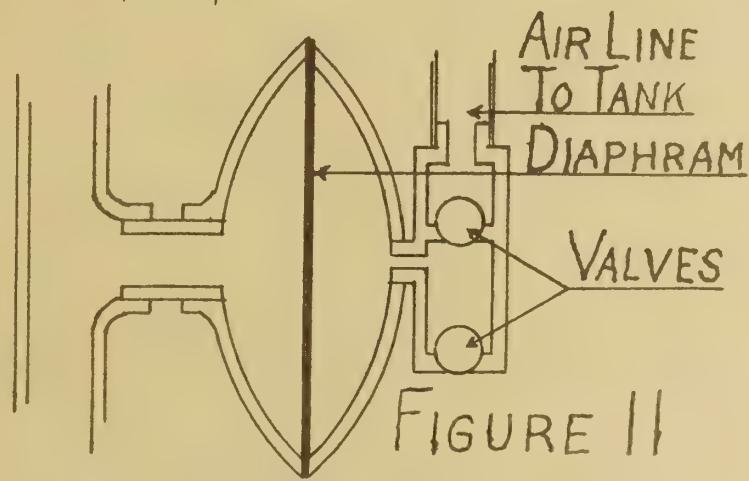
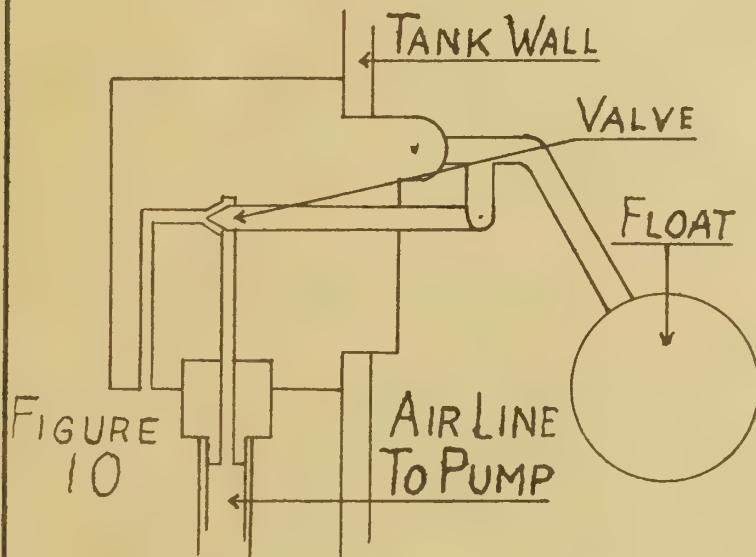
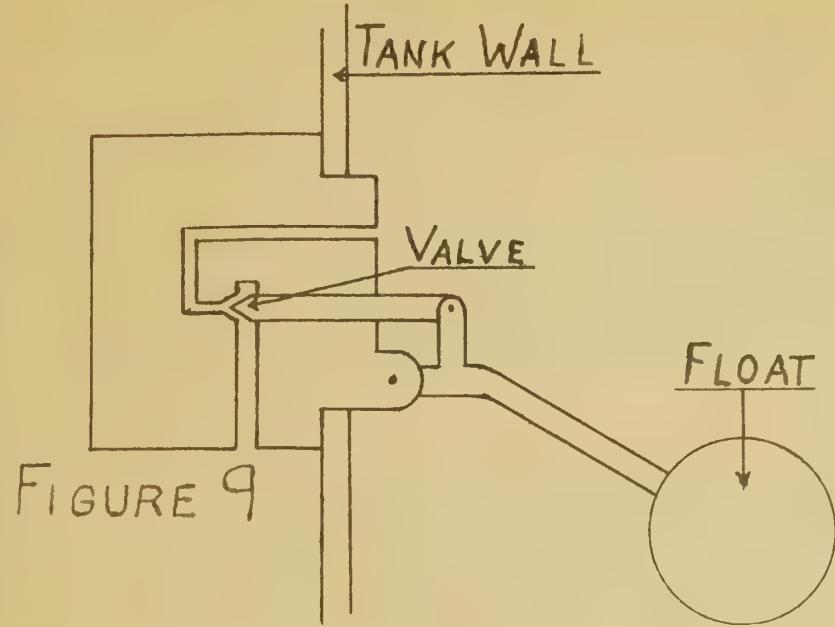
Shallow well pumps and some deep well jet pumps may use either of two common devices. One of these is an opening in the suction side of the pump connected to the air volume control on the storage tank by a small copper tube. A float controlled valve in the air volume control is then opened when the water rises to a certain level in the tank and the pump sucks air through this valve and the copper tube so that air is delivered with the water when the tank needs additional air. This type of air volume control is diagrammatically illustrated in figure 10.

The other device is a combination of an aspirator and an air volume control. The aspirator is a small diaphram enclosed in a housing. The space on one side of the diaphram is connected to either the suction or discharge side of the pump and the space on the other side to the storage tank. If the aspirator is on the suction side of the pump the diaphram is "sucked" to one side by the suction of the pump whenever the pump starts. This draws air, through a small valve, into the housing on the other side of the diaphram. When the pump stops, the suction on the diaphram is released and it returns to its original position forcing a "shot" of air into the tank. If the aspirator is on the discharge side of the pump the diaphram is pushed to one side by the pressure in the discharge pipe each time the pump starts, forcing a "shot" of air from the other side of the diaphram into the tank. When the pump stops the diaphram returns to its original position again filling the space on one side of it with air. Thus the aspirator puts one "shot" of air into the tank each time the pump starts and stops. The excess air is released from the tank by a float controlled valve in the air volume control in the side of the tank. Figure 11 illustrates an aspirator.

Safety Pressure Releases

Safety pressure releases are needed on water systems for two reasons--(1) the motor control switch may fail to function and the pump continue to run until it develops dangerous pressures, and (2) the hot water heater may overheat, developing dangerous steam pressures in the system. All types of pumps except centrifugal (including centrifugal jet combinations) are capable of developing dangerous pressures if the pump is not shut off. Centrifugal pumps reach their maximum pressures within the accepted range of safety and will not develop dangerous pressures even though they continue to run. For this reason, it is important that all pumps except centrifugal be equipped with safety pressure releases located at some point in the piping systems where they cannot be isolated from the pumps by valves. Such a release is commonly sold with the system as a part of it but must be installed in the piping at the time the system is installed.

Usually there are valves of one sort or another which may be closed between the safety release for the pump and the water heater. This makes it necessary to install another pressure safety release in the piping near the water heater. This is tremendously important because steam explosions from overheated water heaters can cause great devastation and often take lives. These release valves do not ordinarily come with the heaters but must be bought separately.





Water Piping

The rate at which water will flow from a pipe depends on the pressure behind the water, the elevation to which this pressure raises it, roughness of the interior surface of the pipe, the size of the pipe, the length of the pipe, and the number of elbows, tees and valves in the pipe.

Height That Water Is Raised

Each foot of water develops a pressure of about .434 pounds. Thus 20 pounds of pressure in a storage tank will raise water a maximum of 46.2 feet. In calculating the flow of water through pipes, it is necessary to subtract the pressure resulting from the height to which the water is raised above the storage tank from the storage tank pressure to determine the effective pressure causing the water to flow.

Roughness of Interior Pipe Surface

There is friction between the water flowing through a pipe and the wall of the pipe. Pressure is required to overcome this friction. The rate of flow of water through a pipe becomes constant at the point where the pressure required to overcome this friction equals the available pressure. Common pipes are either steel or copper. Of these two, copper pipe is the smoother and, therefore, smaller copper pipe than steel pipe will deliver water at a specified rate. As pipe gets older, the interior surface becomes rougher. For this reason, all estimates of the rate of delivery must be based on the assumption of new pipe at the time of installation or the average condition of pipe after it has been in use a certain number of years--say, 10, 15, or 25. This causes considerable variation in estimates unless this condition is specified. Tables of pipe friction are included under the discussion of pipe fittings and size and length of pipe.

Pipe Fittings and Size and Length of Pipe

Most calculations of the amount of water that will flow through a pipe are based on tables of water friction in the different sizes of pipes. Some calculations are based on new pipe. Installations based on these calculations will not deliver the calculated quantities after the pipes become old. Other calculations are based on average pipe of a specified age, such as 10 years, 15 years, or 25 years. Such installations will deliver more than the calculated quantities of water when the installations are new. The tables given below are based on ordinary iron pipe such as may be present after 12 to 15 years of service and on new copper pipe. Copper pipe does not usually roughen as much with age as does with pipe. For new smooth iron pipe, the friction will be about 75% of that given and for 25 years old iron pipe will be about 20% greater. Tables of this type may be given either in terms of loss of pressure in pounds per square inch or in terms of "loss of head" in feet. Conversion from one method to the other is easy if it is remembered that one pound of pressure equals 2.31 feet of head (depth of water) or one foot of head equals .434 pounds of pressure. These tables are most commonly given in terms of "loss of head" so that is the terminology used below.

FRICITION OF WATER IN COPPER TUBING

Loss of Head in Feet* Due to Friction Per 100 Feet of Smooth Pipe (Type L Copper Tubing)**

Gallons Per Min.	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"
	Tubing Feet								
1	8.1	2.8	1.5	46	.86	.32			
2	27.	8.8	3.0	1.4	.52	.23			
3	53.	18.	5.1	2.1	.79	.35			
4	88.	30.	7.6	1.0.	2.9	1.1			
5	130.	43.	10.	14.	3.8	1.4			
6	180.	60.	14.	17.	4.8	1.8			
7	230.	78.	98.	21.	6.0	2.2			
8				120.	7.3	2.7			
9				150.	25.	5.5			
10					51.	9.0			
15					15.	25.			
20					85.	37.			
25					125.	170.			
30					230.	63.			
35						79.			
40						98.			
45						120.			
50									

*From Chart in Figure 7 of Report BMS66, National Bureau of Standards.

**Data is for new copper tubing with recessed soldered joints. It may also be applied to any correspondingly smooth pipe such as brass pipe.

FRICITION OF WATER IN IRON OR STEEL PIPE
Loss of Head in Feet* Due to Friction Per 100 Feet of
Fairly Rough Pipe**

Gallons Per Min.	3/8" Pipe Feet	1" Pipe Feet	3/4" Pipe Feet	1" Pipe Feet	1 1/4" Pipe Feet	1 1/2" Pipe Feet	2" Pipe Feet	2 1/2" Pipe Feet	3" Pipe Feet
1	17.	4.3	.59						
2	64.	16.	2.2	.51					
3	140.	35.	4.6	1.1	.40	.15			
4		60.	8.1	1.9	.70	.27			
5		92.	13.	3.0	1.0	.41			
6		130.	18.	4.2	1.5	.58			
7		175.	25.	5.8	2.0	.79			
8		230.	31.	7.4	2.4	1.0	.25		
9			38.	9.3	3.1	1.2	.31		
10			48.	11.	3.9	1.6	.39		
15			100.	26.	8.5	3.3	.85	.28	
20			180.	43.	15.	6.0	1.5	.48	
25				67.	23.	9.0	2.3	.74	.31
30				97.	32.	13.	3.1	1.1	.44
35				130.	43.	17.	4.2	1.4	.60
40				160.	55.	22.	5.3	1.8	.75
45				220.	69.	28.	6.9	2.3	.96
50					86.	35.	8.6	2.8	1.2

*From chart in Fig. 9 of Report BMS66, National Bureau of Standards.

**Fairly Rough Pipe will approximate in many installations the condition of ordinary iron or steel pipe after it has been in use 12 to 15 years.

Friction of water in an elbow, tee, globe valve or faucet may be assumed to equal that in 10 feet of straight pipe. Friction in gate valves, couplings, and unions may be neglected. A more exact evaluation of friction in these fittings will be found in most water system catalogues, but this assumption is accurate enough for most applications.

The use of friction tables can best be explained by examples.

Example No. 1

Pressure in the storage tank varies from 20 pounds to 40 pounds. How fast will water flow through iron pipe into a stock tank on the same level as the storage tank through 142 feet of 3/4 inch pipe, three 90 degree elbows, and one faucet?

Calculation:

$$\text{Average pressure in tank } \left(\frac{20+40}{2} \right) = 30 \text{ pounds}$$

30 pounds pressure = 30×2.31 or 69.3 ft. of head to overcome friction.

Three 3/4" 90° elbows = 3×10 or 30 ft. pipe. (friction equivalent).

One 3/4" faucet = 10 ft. pipe.

Pipe (3/4") = 142 ft.

Equivalent 3/4" pipe = 182 ft.

Ft. of head to be lost through friction per 100 ft. of pipe $\left(\frac{69.3}{1.82} \right) = 38.07$ ft.

Flow into stock tank (See Friction Table for gal. per min. through 3/4" pipe with 38.07 ft. friction) = 9 gal. per min.

Example No. 2

Pressure in the storage tank varies from 20 pounds to 40 pounds. What size iron pipe shall be used to produce a flow of 5 gallons per minute from the bathroom lavatory faucet if there will be 40 feet of pipe, 3 elbows, and one globe valve in the pipe line, and the lavatory faucet is 10 feet above the storage tank?

Calculation:

$$\text{Average pressure in tank } \left(\frac{20+40}{2} \right) = 30 \text{ pounds}$$

30 pounds pressure = $30 \times 2.31 = 69.3$ ft. of head

Feet of head required to lift water to faucet = 10.

Feet of head available to overcome friction 59.3

Friction in three elbows	=	30 ft. of pipe
Friction in one globe valve	=	10 ft. of pipe
Friction in 1 faucet	=	10 ft. of pipe
Pipe	=	<u>40</u> ft.
Friction equivalent	=	90 ft. of pipe
Equivalent ft. of head available per 100 ft. of pipe		

$$(\frac{59.3}{90} \times 100) = 65.9$$

Size of pipe necessary (See Friction Table for 5 gal. per min. and 65.9 ft. of head) = 3/4"

Note: 1/2" pipe would furnish a little over 4 gal. per min. in this installation since at 4 gal. per min. only 60 feet of friction head would be used. Since $\frac{1}{4}$ " pipe will not furnish the required quantity, 3/4" pipe must be used although it will furnish over 10 gal. per min. with 63.6 feet of head friction loss.

Example No. 3.

Pressure in the storage tank varies from 20 pounds to 40 pounds. A 1" pipe leads from the storage tank and supplies water for the kitchen sink, the bathtub, and the bathroom lavatory. The pipe to the kitchen sink branches off through a tee in the 1" pipe 42 feet from the storage tank and the 1" pipe continues on to serve the bathroom fixtures. There are three elbows in the 1" pipe before it reaches the branch to the sink. From the tee in the 1" pipe to the faucet at the kitchen sink there is 33 feet of pipe with four elbows. The sink faucet is 15 feet above the storage tank. What size pipe will be necessary to the kitchen sink in order that 5 gal. per min. will flow from the sink faucet when 10 gal. per min. are flowing into the bathtub and 5 gal. per min. are flowing into the lavatory?

Calculation:

$$\text{Average pressure in tank } \left(\frac{20+40}{2} \right) = 30 \text{ pounds}$$

$$30 \text{ pounds pressure} = 30 \times 2.31 = 69.3 \text{ ft. of head}$$

$$\text{Feet of head required to lift water to sink faucet} = 15.$$

$$\text{Feet of head available to overcome friction} = 54.3$$

$$\text{Friction in 3 elbows in 1" Pipe} = 30 \text{ ft. of pipe}$$

$$1" \text{ Pipe} = 42 \text{ ft. of pipe}$$

$$\text{Friction equivalent of 1" Pipe} = 72 \text{ ft. of pipe}$$

$$\text{Loss in head of 20 gal. per min. through 1" pipe (from friction table)} (.72 \times 43) = 30.96 \text{ ft.}$$

$$\text{Head remaining to overcome friction in pipe to sink} (54.3 - 30.96) = 23.34 \text{ ft.}$$

$$\text{Friction in 4 elbows & 1 tee} = 50 \text{ ft. of pipe}$$

$$\text{Friction in faucet at sink} = 10 \text{ ft.}$$

$$\text{Pipe to sink} = 33 \text{ ft.}$$

$$\text{Friction equivalent of pipe to sink} = 93 \text{ ft.}$$

Equivalent feet of head available per 100 ft. of pipe

$$\frac{(23.34 \times 100)}{93} = 25.1$$

Size of pipe necessary (See Friction Table for 5 gal. per min. and 25.1 feet of head) = $3/4"$

Note: $1/2"$ pipe would require 92 ft. of head to overcome the friction. Only 25.1 feet is available. Therefore $1/2"$ pipe would not supply the needed water so larger pipe must be used. $3/4"$ pipe would do it with 13 feet available to overcome friction. The actual amount supplied through the $3/4"$ pipe will be about 7 gal. per min., as 7 gal. per min. would require 25 ft. of head.

Water Softeners

Many farm families are accustomed to using hard well water for drinking, and soft cistern water for washing. They want to continue to have both hard and soft water available after the electric water system is installed. This can be and frequently is done by installing separate water systems for the well and for the cistern. If the well is adequate, it can also be done by discarding the cistern and placing a water softener in the well water system in such a way that water to the faucets that are to supply soft water will pass through the softener. This is frequently cheaper than installing a separate system for the cistern water.

Water softeners are simple machines and the cost of operation is negligible. The simplest ones consist of a tank similar to a range boiler in appearance filled with a special sand known as Zeolite. As water passes through the Zeolite, the various calcium and magnesium compounds that make the water hard are removed. After a period of operation, the Zeolite will absorb no more hardness from the water. Common salt is then placed in the softener and washed slowly through the Zeolite and discarded. This removes the calcium and magnesium compounds from the Zeolite leaving it ready to soften the water again. More expensive softeners have a second tank which is filled with salt brine. These softeners are regenerated by opening certain valves and closing others so that some of the brine is forced through the Zeolite.

Both natural and synthetic Zeolite are available. They vary somewhat in their composition, some of the synthetic ones being capable of removing iron and other compounds as well as calcium and magnesium compounds.

Distributors handling water softeners will analyze water samples and recommend the type of Zeolite most suitable to the particular water.

Water Heaters

Water may be heated by an electric water heater, by a range boiler and a water front or back in the kitchen range, or by several other means. Only electric and gas heaters are thermostatically controlled so that they keep hot water at the right temperature available continuously without close attention.

Electric storage water heaters are made in several sizes. The 30-gallon size is very common. However, larger sizes are desirable. They make a larger quantity of hot water available for laundry purposes and other needs for considerable hot water. Many farm families would be well advised to choose a heater of about 80 gallons capacity. The difference in operating cost of the larger sizes over the smaller sizes is negligible. Some electric heaters are equipped with one thermostat and one heating element while others have two thermostats and two heating elements. The latter are to be preferred. Commonly one element is 1,500 watts capacity, while the other is 2,500 watts capacity--the larger one being in the top of the tank and the smaller in the bottom. When only a small amount of water is drawn from the heater, how water remains in the top of the tank and only the lower element comes on to heat the cold water that has come in. When larger quantities are drawn so that the whole tank is cooled, the upper heating element comes on.

On some heaters, the thermostats are independent of each other while on others they are interconnected so that only one heating element may be heating at any one time. The interconnected thermostats are used where it is necessary to limit the load on the wiring system to the 2,500 watt unit.

If the well water is very cold, it may be desirable to pass it through a tempering tank before it enters the heater. Commonly range boilers are used for tempering tanks and they are placed somewhere so that they will pick up some heat. This will reduce the amount of electricity necessary to heat the water.

It is desirable that the heater be located so that the hot water pipes from it to faucets are as short as practical. The water in these pipes cools when the faucets are closed and short pipes will make it necessary to draw less cold water from the faucet before hot water comes. The heat lost from the water in these pipes is wasted electricity. The pipes may be insulated, but usually the faucets are opened so infrequently that the water cools even though there is insulation on the pipes. Unless the pipes are very long, insulation is seldom justified.

Kitchen Sink, Lavatory, Water Closet, Bath Tub, and Shower

The selection of these fixtures is largely a matter of personal preference.

Kitchen sinks with drain boards are not as popular as they formerly were. Too many dishes are broken on the hard drain boards. Those which lack the roll rim and fit flush with the working space seem to be preferred.

No fixtures of any kind with water inlets below the rim of the fixture are to be tolerated. They are a health hazard due to the possibility of siphoning waste water back into the water pipes through the inlets of such fixtures.

Water closets with siphon jets are quieter in operation and use less water than some other types.

Showers have greater application on farms than in practically any other home. Many farm homes have showers over the bath tub as do city homes, but there is also need for a shower in the basement, in the work shop, or in some other building where the farm workers can clean themselves without using the family bathroom.

(See table under Laundry Tubs for rates of water flow to fixtures).

Laundry Tubs

Laundry tubs are heavy equipment. In a well organized farm home, they have a fixed place and are not moved. Also decoration beyond simple neatness is of little consequence. There is no reason why many farmers cannot make them out of concrete although most farmers may prefer to buy them. Their location should consider drainage as well as access to the hot and cold water supply.

The table below gives common rates of water flow to the faucets of various fixtures.

COMMON RATES OF WATER FLOW

<u>Fixture</u>	<u>Rate of Flow</u>
To Bath Tub	10 gal. per minute
To Lavatory	5 gal. per minute
To Water Closet Tank	5 " " "
To Shower	5 " " "
To Sink	10 " " "
To Laundry Tub	10 " " "
Through Garden hose (3/4")	5 " " "
Through Garden hose (5/8")	4 " " "

Fixture Drains

The drain from a fixture leads from the fixture to the soil stack or house drain.

Every drain must include a trap. The purpose of this trap is to prevent sewer gases from getting into the room. Water closets have the traps built into them, but in all other fixtures the traps must be installed beneath the fixture. A special trap known as a drum trap is used on the bath tub. This trap is installed with the top clean-out opening flush with the floor. Other fixtures use S traps or P traps which receive their names from the similarity of their shapes to the alphabetical letters. The drain from a P trap enters the wall back of the fixture while the drain from an S trap enters the floor beneath the fixture. Anti-siphon traps may be either of the S or P type. They are sometimes installed as a substitute for an otherwise adequate installation and are therefore not looked on with favor by many health authorities and plumbing codes. When properly used, anti-siphon traps have a definite place in farm plumbing. In general, anti-siphon traps should be used where the total fixtures installed include not more than a kitchen sink, a lavatory, and laundry tubs, and the disposal system is not suited to handling normal bath room wastes. There will be many installations consisting of merely the pump and the kitchen sink. Such installations seldom justify a complete bath room sewage disposal system, and in such situations anti-siphon traps are to be recommended.

If not more than a kitchen sink, a lavatory, and laundry tubs are installed, the drain may lead from the anti-siphon traps to a line of 4-inch field tile buried about 18" deep. Unless the soil is tight, 50 feet of tile will ordinarily be adequate for a sink and lavatory. One hundred feet of tile will probably be necessary to handle laundry tubs. In tight soils, longer tile lines may be needed. The disposal tile should not be laid near trees or shrubbery or roots may clog it.

Where fixtures other than sinks, lavatories, and laundry tubs are involved, a complete sewage disposal system for handling bath room wastes should be installed.

Soil or Waste Stack and House Drain

The sewage from the fixture drains passes into either the soil or waste stack, or the house drain. The soil or waste stack is the vertical portion of the sewage disposal pipe in the building. It passes down through a wall to the house drain. The upper portion

above the highest fixture drain opens to the outside air through the roof or under an eave and is known as the main vent. The purpose of this main vent is to allow sewer gases to escape to the outside air and to maintain atmospheric pressure throughout the sewage system. Fixture drains are vented individually to this main vent to prevent the water seal from being siphoned from the traps.

The house drain leads from the soil stack to a point at least five feet outside of the house. Local and state plumbing regulations vary widely in their requirements for fixture drains, soil stacks, vents, and house drains. Many of them are actually contradictory. But in general, a 3-inch soil stack and house drain is adequate for farm use. Many 2-inch stacks and drains have been used and are giving satisfactory service but the possibilities of trouble from careless installations with drains this small are enough that they are not to be generally recommended.

There is no reason, other than the desire plumbers have to obtain more work, why the main vent should continue the same size as the soil stack through the roof, although many codes and regulations require it. Generally, a main vent of 1-1/2" pipe is large enough, although, in some of our colder regions, it may be desirable to increase the size to 3" as it passes through the roof and into the outside air to prevent it clogging with ice and frost in the winter.

The installation of house drains and soil stacks is simplified somewhat by the use of threaded rather than bell joint pipe. However, few workmen are equipped to thread pipe 3" in diameter and larger, so that its use requires accurate preliminary measurement and ordering pipe cut to fit.

Sewage Disposal Means

As a general recommendation, a septic tank with a field-drain-tile disposal field is the only acceptable means of disposing of bathroom waste. Cesspools have been widely used but, except in rare cases, are to be avoided. The purification of sewage in the soil depends on the action of aerobic bacteria and molds. These organisms are not present deep in the soil where the air does not penetrate. The seepage from cesspools is ordinarily below this level. The seepage from cesspools is at such a depth that the probability of contaminating the ground water is much greater than when a shallow field-tile disposal field is used. In addition to the sanitary disadvantages of cesspools, the walls of the cesspool commonly become plugged with sewage after a relatively short time and it overflows on the surface of the ground. A new one must then be dug in a new location.

Septic Tanks

A septic tank is merely a closed chamber in which the sewage remains long enough for most of the solid matter to decompose into liquids and gases. The gases escape through leaks in the cover, through vents, through the soil of the disposal field, or through the house drain and the main vent. The bacteria which bring about this decomposition are anaerobic, that is, they live where there is no air. For this reason, it is necessary that the septic tank be so constructed that neither the incoming or outgoing sewage agitate the contents enough to mix air with it. This is sometimes done by placing baffles in the tank in such a manner that the flow through the incoming and outgoing pipes does not disturb the main contents. Many recently constructed tanks accomplish the same thing by having the incoming sewage deposited straight downward at least 12" below the surface of the contents at one end of the tank and having the outgoing sewage taken straight upward from 16" to 18" below the surface at the other end of the tank.

The tank should be large enough to hold 24 to 72 hours of sewage. No septic tank should be smaller than about 500 gallons capacity. Most septic tank troubles result from small size or inadequate disposal fields. A 500-gallon tank is adequate for a family of five people. For larger families and institutions such as schools, 60-gallons capacity should be added for each additional person.

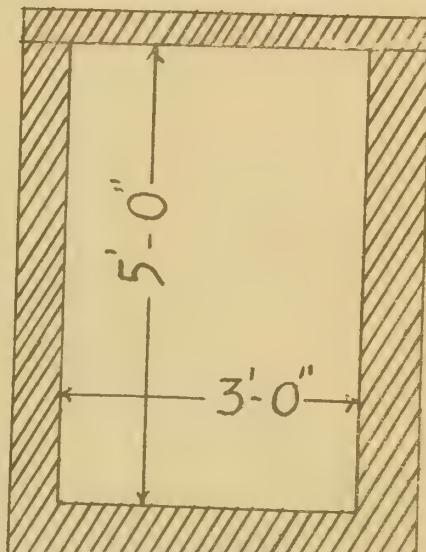
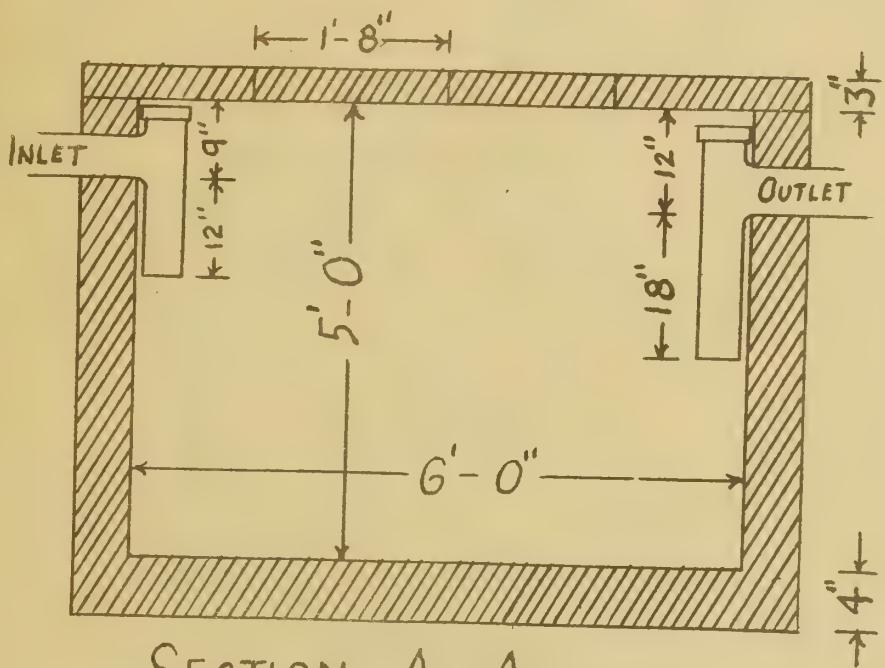
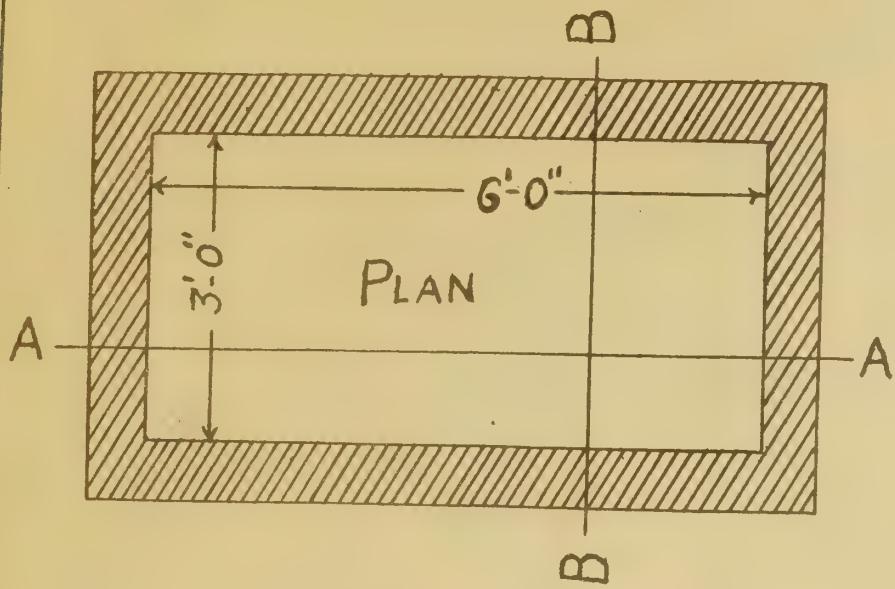
Single chamber tanks are adequate for most families of 10 or less persons. For larger families or institutions, two chamber tanks should be used. The second chamber is merely a reservoir into which the liquid sewage flows from the main chamber whenever sewage enters the main chamber. When the liquid sewage reaches a certain level in this second chamber, a specially designed siphon discharges the sewage to the disposal field. The purpose of this second chamber is to provide this intermittent discharge to the disposal field and thus prevent water logging of the soil. Where less than ten persons use the system regularly, the discharge of the sewage into the tank is infrequent enough to provide the intermittent discharge to the disposal field without the installation of the second chamber and siphon.

Common dimensions for a septic tank for 5 or less people are 6 feet long, 3 feet wide, and 4 feet deep below the outlet level. The length should be about two to three times the width.

The sewer line leading to the septic tank should have a grade of about 1%. The outlet should slope not to exceed 2%.

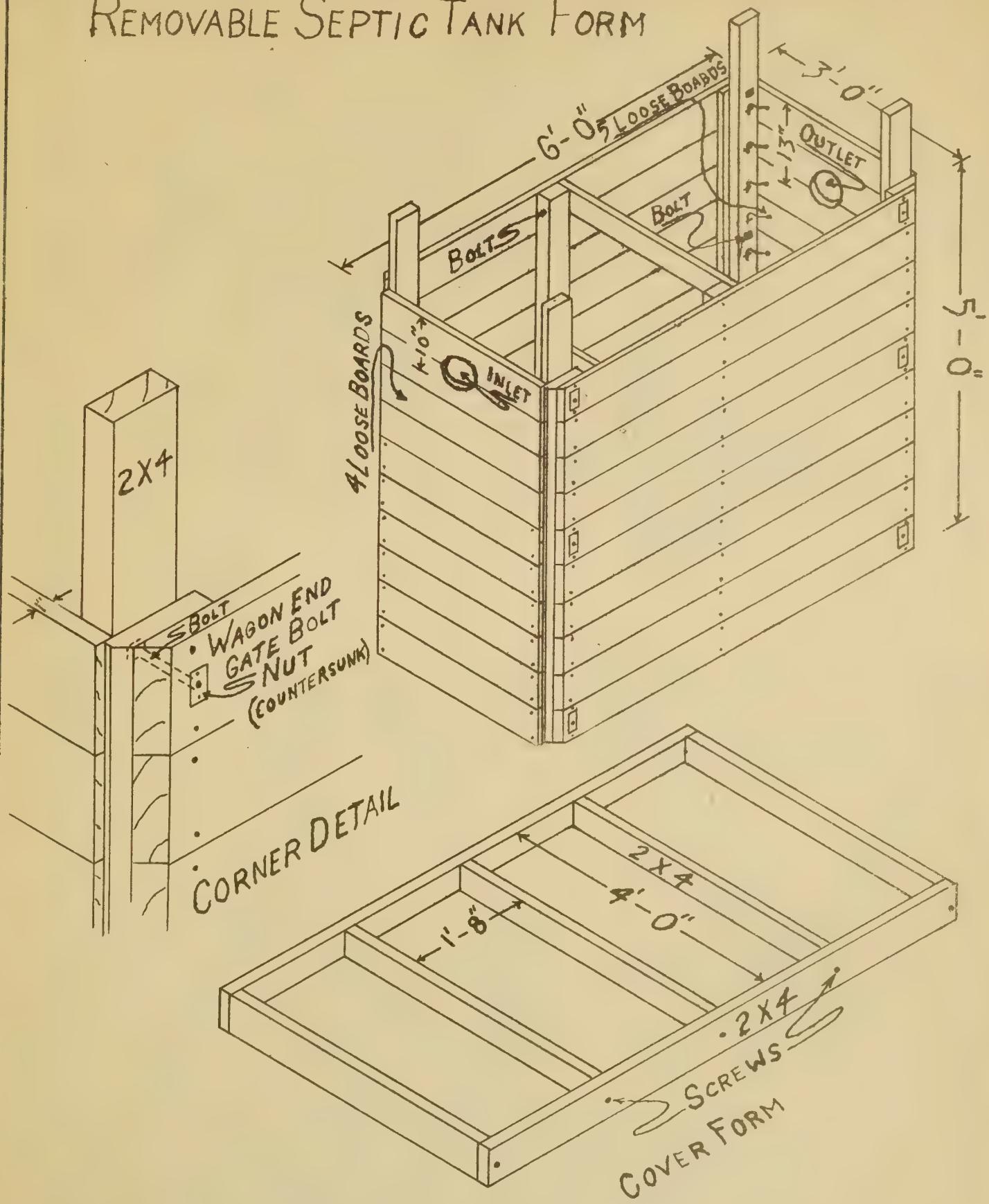
Septic tanks may be made of concrete, tile or steel. Some authorities estimate the life of a No. 12 gauge steel tank to average about ten to fifteen years. A well built concrete or tile tank will last indefinitely. However, the main fault of most steel tanks is that they are too small.

The sewer line from the house to the septic tank must be water tight and the outlet from the septic tank should be water tight to a point at least 100 feet from the well.

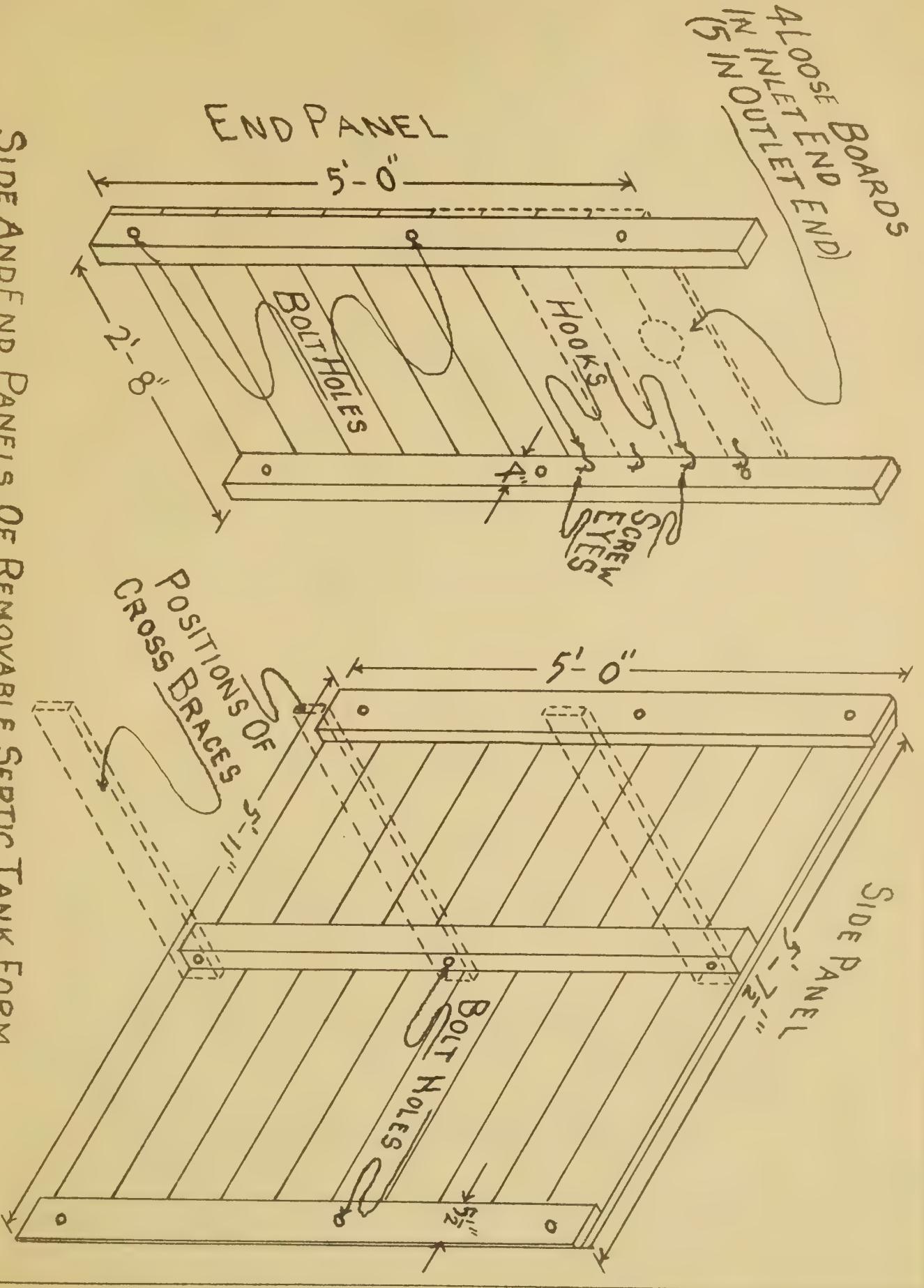


CONCRETE SEPTIC TANK

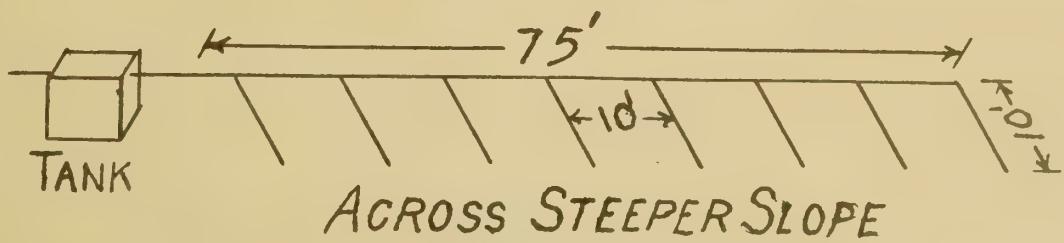
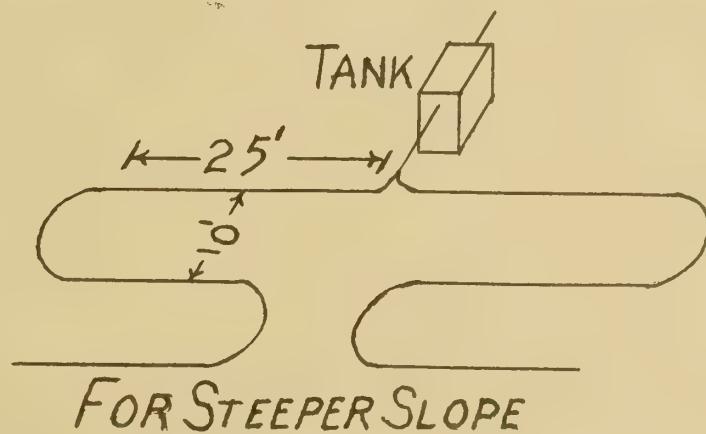
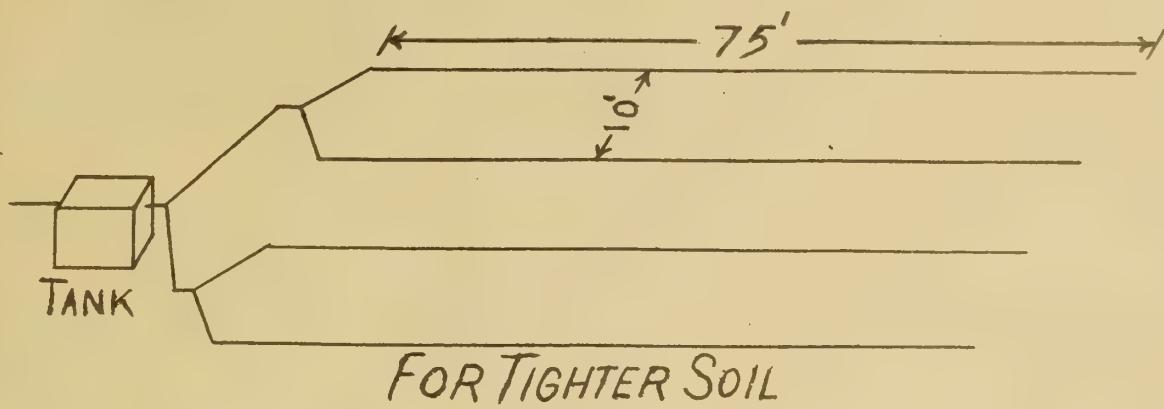
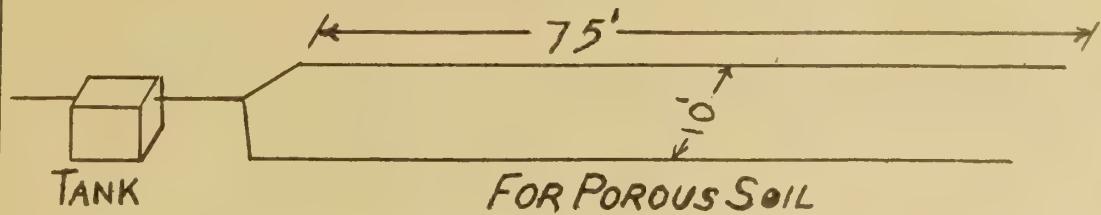
REMOVABLE SEPTIC TANK FORM



SIDE AND END PANELS OF REMOVABLE SEPTIC TANK FORM



TYPICAL LAYOUTS FOR SEPTIC TANK DISPOSAL FIELDS



Contrary to popular opinion, a septic tank does not make sewage fit to drink. It merely decomposes solids. The effluent from the tank is still sewage. Purification takes place in the soil after the sewage has seeped from the disposal tile and has been acted on by aerobic organisms.

Disposal Fields

Septic tank disposal fields are commonly made of ordinary 4-inch field drain tile buried about 18 inches in the soil. Many of them consist of a single line of tile, but it is usually better practice to have the tile line fork into two or more branches. This will decrease the possibility of the soil near the septic tank becoming water logged while that farther away receives no sewage. If the installation serves 10 or more people or is in very tight soil it is desirable to provide two separate disposal fields served through a distribution box located between the septic tank and the disposal fields. A switch in this box permits selection of the field to be used. Changing the switch at intervals of 2 or 3 months allows each field periods of rest and tends to avoid failure of the system.

Tile lines in a disposal field should be at least ten feet apart and no seepage should be permitted within 100 feet of a well.

Trees and shrubs should be cleaned from the seepage area. Otherwise roots may enter the tile and clog it. Lawns and gardens are ordinarily good locations for disposal fields.

The amount of tile needed in a disposal field depends on the type of soil as well as the amount of sewage handled. A rule of thumb for average soils is no disposal field of less than 150 feet of tile and 20 to 50 feet of tile per person served. In very tight soils under drainage may be necessary. This might consist of drain tile a foot below the seepage tile with bank run gravel between. In many of the tighter soils, it is best to have a couple of inches of gravel under the seepage tile and 6 inches to a foot of gravel over it.

Grease Traps

Septic tanks and disposal fields may be plugged by grease. For this reason, it is sometimes desirable to have the drain from the kitchen sink pass through a grease trap before it reaches the septic tank. If the septic tank and disposal field are adequate this is usually not necessary in ordinary farm family installations. Grease traps should always be provided in institution installations if sinks drain into the septic tank. A grease trap is merely a chamber so designed that the grease will accumulate in it and not pass to the septic tank.

Dairy Water Heaters

Dairy water heaters are commonly of two types--the small portable type and the storage type similar to domestic water heaters. The choice will depend on the individual situation.

Watering Troughs

Concrete, steel, and wooden watering troughs are most common. The concrete ones are the most durable and generally to be preferred. The water level in the trough can be maintained by a float controlled valve on the water line to the trough, or the trough can be filled by a manually controlled hydrant. If it is manually controlled, a frost proof hydrant is to be preferred. Such hydrants are so built that when they are shut off a valve is opened below ground level and all of the water in the riser from the underground pipe is allowed to drain away in the soil.

Individual Livestock Drinking Cups

Continually available water definitely increases the milk production of dairy cows. Individual drinking cups also decrease the labor necessary in handling the dairy herd. An adequate installation usually consists of one cup for each two stanchions. Two cows thus use one cup.

Lawn and Garden Watering Equipment

A wide variety of types and styles of lawn and garden watering equipment is on the market. Most of it works. In spite of advertising claims, none of it will give an even distribution of water over the entire watered area. Most of it will fall into four groups (1) overhead pipe lines, (2) rotary sprinklers, (3) stationary sprinklers, and (4) porous hose.

Overhead pipe line systems are expensive but are preferred by many truck gardeners. They allow close working of the rows. The better ones oscillate the pipe through about a 90 degree arc so that the ground is sprinkled first on one side of the pipe line then on the other. Such systems commonly use from 40 to 60 gallons of water per minute per 100 feet of pipe line.

Rotary sprinklers distribute the water in a circle or in an arc of a circle about the place where the sprinkler is located. They vary widely in style, price, evenness of distribution of water and durability.

Stationary sprinklers are usually cheap devices. Some of them are quite satisfactory but are usually used when only small areas are to be watered.

Porous hose is made of canvas tube. The water oozes from the hose throughout its entire length. It is laid along the rows in the garden or on the lawn and must be moved at regular intervals to water a wide area. This type of watering is not effected by wind as are the sprinkler types.

The amount of water needed varies with the soil and crop but, in general, crops need about one inch of water every ten days. About 28,000 gallons are needed for one inch of water on an acre. Thus, about 300 gallons an hour would be needed to place one inch of water on 1/8 acre in 12 hours.

USEFUL INFORMATION

1. For table of the maximum practical suction lifts of pumps at different altitudes see page 4.
2. For table of "Friction of Water in Pipes" see pages 12-13.
3. For table of "Common Rates of Water Flow" to Fixtures see page 19.
4. Common farm water requirements when water under pressure is available.

<u>Use</u>	<u>Quantity</u>
Each member of family	35 gal. per day
Each milking cow	35 gal. per day
Each horse, dry cow, or beef cow	12 gal. per day
Each hog	3 gal. per day
Each sheep	2 gal. per day
Each 100 chickens	3 gal. per day

5. Conversion Factors.

Weight of 1 cu. ft. of water at 62° F. = 62.355 lbs.

Weight of 1 U.S. gallon of water at 62° F. = 8.3356 lbs.

1 cu. ft. = 7.48 U.S. gallons

1 U.S. gallon = .134 cu. ft.

1 U.S. gallon = .833 Imp. gallons

1 Imp. gallon = 1.2 U.S. gallons

1 Barrel = 42 U.S. gallons

6. Capacity of round cisterns and tanks per foot of depth.

<u>Diameter of tank in feet</u>	<u>No. U.S. Gallons</u>	<u>Diameter of tank in feet</u>	<u>No. U.S. Gallons</u>
1	5.87	11	710.90
$1\frac{1}{2}$	13.22	$11\frac{1}{2}$	776.99
2	23.50	12	845.35
$2\frac{1}{2}$	36.72	$12\frac{1}{2}$	918.00
3	52.88	13	992.91
$3\frac{1}{2}$	71.97	$13\frac{1}{2}$	1070.80
4	94.00	14	1151.50
$4\frac{1}{2}$	118.97	$14\frac{1}{2}$	1235.30
5	146.88	15	1321.90
$5\frac{1}{2}$	177.72	$15\frac{1}{2}$	1411.50
6	211.51	16	1504.10
$6\frac{1}{2}$	248.23	$16\frac{1}{2}$	1599.50
7	287.88	17	1697.90
$7\frac{1}{2}$	330.48	$17\frac{1}{2}$	1799.30
8	376.01	18	1903.60

WATER SUPPLY

6. Capacity of round cisterns and tanks per foot of depth-continued

Diameter of tank in feet	No. U.S. Gallons	Diameter of tank in feet	No. U.S. Gallons
8 $\frac{1}{2}$	424.48	18 $\frac{1}{2}$	2010.80
9	475.89	19	2120.90
9 $\frac{1}{2}$	530.24	19 $\frac{1}{2}$	2234.00
10	587.52	20	2350.10
10 $\frac{1}{2}$	640.74		

7. Cost of Operating Electric Pumps

Motor H.P.	Average Watts input to 1-phase motors at full load	Cost per hour for continuous operation when electric rate is 3¢/kwh.
1/6	207	.0063
1/4	305	.0093
1/3	408	.0123
1/2	535	.0162
3/4	760	.0228
1	990	.0297
1 $\frac{1}{2}$	1500	.0300
2	1970	.0591
3	2950	.0885
5	4650	.1395

8. Minimum Wire Sizes for Power Lines to Pump Motors (W.P. Insulation)

H.P. of Motor Single Phase	Distance in Feet from Transformer								
	10	100	200	300	400	500	600	700	800
	to 100	to 200	to 300	to 400	to 500	to 600	to 700	to 800	to 900
110-V 220-V	Minimum Wire Sizes								
1/4	12	12	12	12	12	12	10	10	10
1/3	12	12	12	12	12	10	10	10	10
1/4	12	12	12	10	10	10	8	8	8
1/3	12	12	10	10	10	8	8	8	8
1/2	1	10	10	8	8	6	6	6	6
3/4	10	10	8	8	6	6	6	4	4
1	2	10	8	6	6	4	4	4	4
1 $\frac{1}{2}$	3	8	8	6	4	2	2	2	1
2	5	6	6	4	2	1	1	0	0
3	7 $\frac{1}{2}$	6	4	2	1	0	0	0	000

(See wiring specifications for minimum size of outdoor spans of wire for mechanical strength as well as electrical conductance.)

9. Conversion of Units of Power

<u>Unit</u>	<u>Horse-power</u>	<u>Ft-lbs per minute</u>	<u>Watts</u>	<u>Kilowatts</u>	<u>BTU per minute</u>
1 H.P.	1	33,000	746	.746	42.4
1 Ft-lb/min.	.0000303	1	.0226	.0000226	.001285
1 Watt	.001340	44.2	1	.001	.0568
1 K.W.	1.341	44,250	1000	1	56.8
1 BTU/min.	.0236	778.4	17.6	.0176	1

10. Data on American Standard Steel Pipe

<u>Nominal size</u>	<u>Diameters</u>			<u>Thickness</u>	<u>Weight per foot</u>	<u>Weight of water per foot</u>
<u>External</u>	<u>Internal</u>	<u>Inches</u>	<u>Inches</u>	<u>Inches</u>	<u>Pounds</u>	<u>Pounds</u>
1/8	.405	.269		.068	.24	.025
1/4	.540	.364		.088	.42	.045
3/8	.675	.493		.091	.56	.083
1/2	.840	.622		.109	.85	.132
3/4	1.050	.824		.113	1.13	.231
1	1.315	1.049		.133	1.67	.375
1 1/4	1.660	1.380		.140	2.27	.65
1 1/2	1.900	1.610		.145	2.71	.88
2	2.375	2.067		.154	3.65	1.45
2 1/2	2.875	2.469		.203	5.79	2.07

11. Capacities of Typical Water Softeners.

Hardness in water is commonly measured in terms of grains.

Hard water may be expected to have from 5 to 50 grains of hardness per gallon. It is best to have a chemical analysis of the water before the softener is bought and then to select a softener that will need regeneration not oftener than once a week - a size that will need regeneration only once in two weeks is still better.

One well-known manufacturer gives the following capacities for his softeners between regenerations:

<u>Size of Tank</u>	<u>Flow rate</u>	<u>Wt. of Zeolite</u>	<u>Grains of hardness removed</u>
<u>Diameter</u>	<u>Height</u>	<u>G.P.M.</u>	<u>Pounds</u>
11"	66"	6	55
13"	66"	8	110
17"	66"	14	165
19"	66"	18	220
23"	66"	26	330
25"	66"	32	440

For Combination Softener and Iron Remover

Size of Tank Diameter	Height	Flow rate G.P.M.	Wt. of Zeolite Pounds	Grains of hardness removed
11"	66"	6	50	8,000
13"	66"	8	100	16,000
17"	66"	14	150	24,000
19"	66"	18	200	32,000
23"	66"	26	300	48,000
25"	66"	32	400	64,000

Gallons of Water Softened Between Regenerations

Size of Tank Dia.	Ht.	Grains of Hardness per Gallon									
		5 Gal.	10 Gal.	15 Gal.	20 Gal.	25 Gal.	30 Gal.	35 Gal.	40 Gal.	45 Gal.	50 Gal.
11"	66"	2400	1200	800	600	480	400				
13"	66"	4800	2400	1600	1200	960	800	685	600	533	480
17"	66"	7200	3600	2400	1800	1440	1200	1028	900	800	720
19"	66"	9600	4800	3200	2400	1920	1600	1370	1200	1066	960
23"	66"	14400	7200	4800	3600	2880	2400	2056	1800	1600	1440
24"	66"	19200	9600	6400	4800	3840	3200	2750	2400	2132	1920

For Combination Softener and Iron Remover

11"	66"	1600	800	533	400						
13"	66"	3200	1600	1066	800	640	533	457	400		
17"	66"	4800	2400	1600	1200	960	800	685	600	533	480
19"	66"	6400	3200	2132	1600	1280	1066	914	800	711	640
23"	66"	9600	4800	3200	2400	1920	1600	1370	1200	1066	960
24"	66"	12800	6400	4264	3200	2560	2132	1828	1600	1422	1280

Special softeners and conditioners are made to meet many special conditions. They contain special chemicals and can be obtained to neutralize acid, remove undesirable tastes and odors, etc.

12. Installing Pumps

Always study and follow the directions that come with the particular pumps.

A. Shallow Well

1. Location

- Select a conveniently accessible location, that is clean, dry, well ventilated, and frost proof. It need not be directly over the well.
- Place pump and tank on a solid foundation slightly above floor level. Provision for air circulation under the tank will prolong its life.

- c. Provide for as straight and short suction line to the well as is practical.
- d. Check on local health and milk requirements.

2. Suction Pipe to Well.

- a. Must slope continuously upward from the water in the well to the pump.
- b. Size must not be smaller than opening in the pump to which it connects. It may need to be larger. Use the table on "Friction of Water in Pipes" on page 12 to calculate size of long suction pipes. Remember that friction in the pipe amounts to the same thing as increased depth to water.
- c. Put strainer and foot valve on lower end of pipe in the well.

3. Supply pipe from pump to tank.

- a. Slope pipe continuously upward from pump to tank.
- b. Install pressure relief valve in piping near the pump where it cannot be isolated from the pump by a valve.
- c. Connect automatic motor control switch to tank or to supply line to tank if tank is at a distance from pump.

4. Connect air volume control.

5. Connect electrical wiring according to wiring specifications.

6. Check the lubrication - follow directions with the pump.

7. Check belt tension - adjust if necessary.

8. Turn pump and motor by hand to see that all moving parts are free to move.

9. Prime the pump.

10. Close the switch and start the pump - the pump may have to be primed again before it starts to pump water.

11. Do not cover pipe in ditches until pump has been in operation for at least 24 hours.

B. Deep Well Reciprocating (including differential)

1. Location

- a. The pumping head must be directly over the well, as it is usually best to mount it on the concrete well curb.

2. Weather Protection.

- a. A weatherproof, frostproof pump house may be built over the well.
- b. The pump may be placed in a masonry pit over the well if the pit is well drained.
- c. A Frost Proof Set length may be installed in the well beneath the pumping head. This provides underground discharge below frost level.

3. Drop Pipe and Open End Cylinder.

- a. Attach cylinder to lower end of drop pipe and lower into well.
- b. Attach foot valve to lower end of pump rod.
- c. Lower pump rod with attached foot valve (without plunger) into drop pipe until foot valve seats in bottom of cylinder. Tap rod lightly with block of wood to seat valve. Turn rod counter-clockwise to unscrew check valve. Remove rod from well.
- d. Attach plunger to lower end of pump rod.
- e. Lower pump rod with attached plunger into drop pipe.
- f. Place pumping head in position. Turn it by hand to the bottom of the stroke. Raise pump rod 2 inches by hand, cut and fit it to the pumping head in this position.

4. Drop Pipe and Closed End Cylinder.

- a. Assemble cylinder including plunger and foot valve.
- b. Attach first section of pump rod to plunger.
- c. Slip first section of drop pipe over pump rod and attach to cylinder.
- d. Lower cylinder into well and attach additional sections of pump rod and drop pipe as it goes down.
- e. Place pumping head in position. Turn it by hand to the bottom of the stroke. Raise pump rod 2 inches by hand, cut and fit it to the pumping head in this position.

5. Check lubrication - follow directions with the pump.

6. Check belt tension and adjust if necessary.

7. Turn pump and motor by hand to be sure that all moving parts are free to move.

8. Connect tank, automatic motor switch, air volume control, pressure relief valve, and electric wiring as for shallow well pumps.
9. Close the switch and start the pump.

C. Deep Well Jet

1. Location - same as for shallow well pumps.
2. Drive and delivery pipes from well to pump.
 - a. Must slope continuously upward from water in the well to the pump.
 - b. Jet, jet body, and venturi are assembled on the lower ends of the drive and delivery pipes and lowered into the water in the well. Foot valve and strainer are attached below the jet body.
 - c. Size must not be smaller than openings in the pump to which they connect. They may need to be larger. Use the table on "Friction of Water in Pipes" on page 12 to calculate size of long delivery pipes. Drive pipes may be one size smaller. Remember that friction in the pipes amounts to the same thing as increased depth of well.
3. Supply pipe from pump to tank - same as for shallow well pumps except that most jet pumps require the installation of a control valve at the outlet of the pump.
4. Connect air volume control, automatic motor switch and electric wiring as for shallow well pumps.
5. Prime the pump-follow the directions with the pump.
6. Close the switch and start the pump.
7. Do not cover pipes in ditches until pump has been in operation for at least 24 hours.

13. Percolation Test for Determining the Amount of Seepage Tile Needed in a Septic Tank Disposal Field

- A. Dig a hole 1 foot square and to a depth equal to that at which the seepage tile is to be laid.
- B. Fill the hole with water and allow the water to seep away.
- C. While the bottom of the hole is still moist fill the hole with water to a depth of 6 inches.

D. Observe the time required for the water level to fall 1 inch.

E. Repeat the above procedure at several places throughout the proposed disposal field.

F. Calculate the average time required for the water level to fall 1 inch in the test holes.

G. Estimate the amount of the required from the data in the following table.

<u>Minutes required for water to fall 1 inch</u>	<u>Feet of 4" tile required per person</u>
2	15
5	20
10	30
30	60
60	80
over 60	Under-drain should be used